

We claim:

1. A method for forming integrated circuit copper lines,
comprising:

5 forming a trench in a dielectric layer;

 forming a first metal layer in said trench using
 physical vapor deposition and a high atomic
 number metal;

10 forming a second metal layer in said trench over
 said first metal layer using chemical vapor
 deposition and a high atomic number metal; and

15 filling said trench with copper by electroplating
 copper directly on said second metal layer.

2. The method of claim 1 wherein said high atomic number
metal is selected from a group consisting of Ruthenium,
20 Iridium, Rhodium, and Palladium.

3. The method of claim 1 wherein said forming a first metal
layer in said trench comprises forming a Ruthenium layer
using a plasma excitation power of 100 to 1000 watts with

a DC power of 5KW to 30 KW applied to a sputter metal target.

4. The method of claim 1 wherein said forming a second
5 metal layer in said trench comprises flowing a vapor
containing Ruthenium over a surface heated to between 100°C
and 350°C.

5. The method of claim 1 further comprising forming a third
10 metal layer in said trench over said first metal layer and
beneath said second metal layer using chemical vapor
deposition and a high atomic number metal.

6. The method of claim 5 further comprising forming a
15 fourth metal layer in said trench over said third metal
layer and beneath said second metal layer using chemical
vapor deposition and a high atomic number metal.

7. A method for forming integrated circuit interconnect copper lines, comprising:

forming a trench in a dielectric layer;

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forming a first metal layer in said trench using a plasma excitation power of 100 to 1000 watts with a DC power of 5KW to 30 KW applied to a sputter metal target comprising Ruthenium;

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forming a second metal layer in said trench over said first metal layer wherein said forming a second metal layer comprises flowing a vapor containing Ruthenium over a surface heated to between 100°C and 350°C.; and

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filling said trench with copper by electroplating copper directly on said second metal layer.

20 8. The method of claim 7 wherein said first metal layer is less than 50A thick.

9. The method of claim 7 further comprising forming a third metal layer in said trench over said first metal layer and beneath said second metal layer using chemical vapor deposition and a high atomic number metal.

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10. The method of claim 9 further comprising forming a fourth metal layer in said trench over said third metal layer and beneath said second metal layer using chemical vapor deposition and a high atomic number metal.

11. An integrated circuit copper interconnect structure,
comprising:

a trench formed in a dielectric layer;

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a first metal layer formed in said trench using
physical vapor deposition and a high atomic
number metal;

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a second metal layer formed in said trench over
said first metal layer using chemical vapor
deposition and a high atomic number metal; and

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a copper structure formed directly on said second
metal layer that fills said trench wherein said
copper structure is formed by electroplating.

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12. The method of claim 11 wherein said high atomic number
metal is selected from a group consisting of Ruthenium,
Iridium, Rhodium, and Palladium.

13. The method of claim 11 wherein said first metal layer
comprises a Ruthenium layer formed using a plasma

excitation power of 100 to 1000 watts with a DC power of 5KW to 30 KW applied to a sputter metal target.

14. The method of claim 13 wherein said second metal layer
5 comprises a Ruthenium layer formed by flowing a vapor containing Ruthenium over a surface heated to between 100°C and 350°C.

15. The method of claim 11 further comprising a third metal
10 layer formed over said first metal layer and beneath said second metal layer using chemical vapor deposition and a high atomic number metal.

16. The method of claim 15 further comprising a fourth
15 metal layer formed over said third metal layer and beneath said second metal layer using chemical vapor deposition and a high atomic number metal.

17. A method for forming circuit copper lines, comprising:

forming a trench in a dielectric layer;

5 forming a first metal layer in said trench using
physical vapor deposition and a high atomic
number metal;

 exposing said first metal layer to a plasma
10 treatment;

 forming a second metal layer in said trench over
said first metal layer using chemical vapor
deposition and a high atomic number metal; and

15 filling said trench with copper by electroplating
copper directly on said second metal layer.

18. The method of claim 17 wherein said forming a first
20 metal layer in said trench comprises forming a Ruthenium
layer using a plasma excitation power of 100 to 1000 watts
with a DC power of 5KW to 30 KW applied to a sputter
metal target.

19. The method of claim 18 wherein said forming a second metal layer in said trench comprises flowing a vapor containing Ruthenium over a surface heated to between 100°C and 350°C.

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20. The method of claim 19 wherein said plasma treatment comprises exposing said first metal layer to a plasma with excitation power levels of less than 1000 Watts.

10 21. The method of claim 20 further comprising forming a third metal layer in said trench over said first metal layer and beneath said second metal layer using chemical vapor deposition and a high atomic number metal.

15 22. The method of claim 21 further comprising forming a fourth metal layer in said trench over said third metal layer and beneath said second metal layer using chemical vapor deposition and a high atomic number metal.